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# EFFECT OF CARBONATION ON THE CHEMICAL COMPOSITION AND SHELF LIFE OF CARROT JUICE

**Azam Shakeel[1], Hafiz Khuram Wasim Aslam[1], Muhammad Shoaib[2], Hafiz Arbab Sikandar[3], Nighat Naheed[4] and Muhammad Siddique Raza[1]**

**[1]National Institute of Food Science and Technology, University of Agriculture Faisalabad-Pakistan**
**[2]State Key Laboratory of Food Science and Technology, Synergetic Innovation Center of Food Safety and Nutrition, School of Food Science and Technology, Jiangnan University, Wuxi, Jiangsu 214122, People's Republic of China**
**[3]Microbiology Department, Quaid-I-Azam, University Islamabad-Pakistan**
**[4]Institute of Horticultural Sciences, University of Agriculture Faisalabad-Pakistan**
***Corresponding author's e-mail: azam1087@gmail.com**

Carrot (*Daucas carota)* is considered as important agricultural crop for human consumption. Carrot juice has very short shelf life and in this study the carbonation was carried out to study its effect on the shelf life, physico-chemical properties and the organoleptic properties. The carrot juice was prepared and its carbonation was done. After carbonation different treatments were stored in colored and transparent bottles. These treatments were observed at regular intervals of time i.e. 0, 15, 30 and 45 days. The carbonation brought decrease in pH, ascorbic acid, sugar contents and increase in Total Soluble Solids (TSS). The mineral stability of carbonated carrot juice maintained which remained acceptable for its color, flavor, taste and overall acceptability during storage. There was no significant difference in the carbonated carrot juice stored in transparent and colored bottles except the ascorbic acid contents which were high in colored bottles at 45$^{th}$ day than transparent bottles due to less penetration of light in colored bottles.
**Keywords:** Shelf life, *Daucus carota,* TSS, Carbonation, Storage

## INTRODUCTION

Carrot is a plant of ancient cultivation especially in the countries bordering the Mediterranean Sea. The wild ancestors of carrot are from Afghanistan, which remain the center of diversity of *D. Carota* (Alimula, 1989). Carrots are cultivated on an area of 13.9 thousand hectares, with 242.3 thousand tons production (FAO, 2007-2008). In Pakistan carrot production during 2005-06 was 187 thousand metric tons (Anonymous, 2006). It occupies a prominent position owing to its dietetic and economic values. Its root is used as vegetable constituent in soups, stews and curries. The grated carrot used as salad while tender root as pickle (Alimulla, 1988). Fresh fruits and vegetables have been used by man from ancient time. These not only provide energy to the body but also are good source of vitamins and minerals (Van-Aradal, 1963). Fresh carrot juice contains water 86.4%, carbohydrate 8.0 %, protein 0.8 % and dietary fiber 0.2 % (Salunkle *et al.*, 1973). Moreover the carrot juice is also well known due to its medicinal values as it is effective against urogenital diseases (Salunkle, 1973). Bao and Chang (1994) reported that carrot pulp contained 4-5% protein, 8-9% reducing sugars and 5-6% minerals. Carrot juice has very short shelf life. Normally the juice of carrot is only available in winter. Due to this it is not possible to market it commercially at large scale. Shelf life of juice can be enhanced by various methods like canning, heat treatments, chemical preservatives and carbonation. But among this carbonation is most effective as it does not destroy the nutrient contents of the product (Elahi, 1979). Carbonation of juice not only improves shelf life but also enhances the organoleptic properties of the product (Alimulla, 1988; Shakeel, *et al*., 2013). Ueda (1987) conducted the studies on carbonation of carrot juice and noticed that shelf life of juice was increased up to 250% without using any preservative. Vyrodova *et al.* (1988) conducted study on chemical composition of carrot juice and reported that beta-carotene contents were 5.90 mg/100 mL. Chen *et al.* (1995) detected the changes of carotene, color and vitamin C contents during processing of carrot juice. The effects of various processing methods on the carrot juice carotene, color and vitamin C contents were studied. The canning resulted in highest destruction of carotene. Carrot juice color changed from red to yellow during processing. The vitamin C contents decreased along with increasing temperature and storage time.

The main objective of this study was to evaluate the stability of carrot juice during storage that was subjected to carbonation and to determine the effects of carbonation on the physico-chemical properties of carrot juice but the main purpose was to stabilize the keeping qualities of carrot juice so that it remains useable for sufficiently long time.

## MATERIALS AND METHODS

***Raw Material*:** Fresh and good quality carrots were brought from local market of Faisalabad to the canning hall of National Institute of Food Science and Technology, University of Agriculture, Faisalabad. Washing of carrots was done with tap water and washed carrots were manually trimmed, peeled in abrasive peeler and cut into small pieces

with a knife. After that carrots were subjected to blanching for 3 minutes. Then juice was extracted with the help of juicer machine (National, Japan). Juice was filtered with muslin cloth and carbonation was done with $SP_3$ machine (Germany).

***Carbonation:*** After the extraction and filtration of carrot juice, carbonation was done. Five treatments were applied which are as follows in Table 1.

***Processing of Carrot Juice*:** Carbonated carrot juice was stored in two different types of sterilized glass bottles i.e. transparent and colored bottles. These bottles of carbonated juice were stored at ambient temperature for 45 days. Physico-Chemical analysis of carbonated carrot juice was performed at zero time of storage and after every 15 days periodically. Following characteristics were analyzed. The pH of carbonated carrot juice was determined by digital pH meter (Model HI 9020 Microprocessor pH meter) with the method given by Rangana (1991). Total soluble solids were observed by using hand refractometer as described by Ruck (1963) and expressed as $^0$Brix. The method of Bauernfield (1962) was followed with slight modification for beta-carotene contents determination.

Beta-carotene (µg/ml) = µg/ml from graph * 15.15/wt. of sample.

Sugars were determined by using Lane and Eynon method given by Ruck (1963). The reducing sugars were determined by following formula:

% Reducing sugars = Fehling solution's factor X 100 X dilution/ volume of sample used

***Mineral Analysis:*** Mineral analysis of carbonated carrot juice was carried out by following the method of Richards (1968). But before the analysis wet digestion was performed in which 1 gram of each sample was taken separately into 100 mL conical flask. Then 10 ml of concentrated nitric acid was added in each sample. The contents of flask were heated for 20-30 minutes. After cooling 5 mL of per chloric acid was added. The contents of flask were heated vigorously till volume was reduced to 2-3 mL. The contents were diluted up to 50 mL by adding de-mineralized water. These digested diluted samples were used for the estimation of minerals.

***Organoleptic Evaluation*:** Organoleptic evaluation of carrot juice was carried out after each storage interval of 15 days for color, flavor, taste and overall acceptability by the scoring method as described by Harry and Hildegrade (1998). The analysis of the data was conducted by the method described by Steel *et al.* (1997).

## RESULTS AND DISCUSSION

***pH contents of carbonated carrot juice stored in transparent and colored bottles*:** Analysis of variance regarding pH of carrot juice stored in transparent and colored bottles indicated that effect of treatment and storage was significant. However, interactive effect of treatments and storage was found to be non-significant. Mean value for pH of carbonated carrot juice stored in transparent and colored bottles are given in Table 1. The results showed that with the increase in carbonation, pH of juice was decreased significantly likewise with the storage. The maximum pH was observed at the start of experiment (3.90) both in case of colored and transparent bottles and minimum pH was observed at the 45$^{th}$ day of storage i.e. 3.58 in case of transparent bottles and 3.60 in case of colored bottles.

**Table 1: Treatment plan**

| Treatments | Concentration of $CO_2$ (%) |
|---|---|
| $T_0$ | 0 |
| $T_1$ | 1 |
| $T_2$ | 1.5 |
| $T_3$ | 2 |
| $T_4$ | 2.5 |

The result indicated that there was a significant decrease in pH of carbonated carrot juice stored in transparent and colored bottles. The decrease in pH was due to formation of carbonic acid after carbonation of carrot juice. Carbonic acid was produced by the reaction of $CO_2$ and water that lowers the pH. No significant difference in pH was noted in transparent and colored bottles.

***Total soluble solids (TSS) contents of carbonated carrot juice in transparent and colored bottles*:** Analysis of variance of TSS of carrot juice indicated that effect of treatment and storage was significant in case of both transparent and colored bottles while the interactive effect of treatments and storage was significant too in case of transparent bottles and non – significant in case of colored bottles. Mean values for the TSS of carbonated carrot juice stored in transparent and colored bottles are given in Table 2. The results showed that the TSS increased with increase in carbonation both in case of transparent and colored bottles. The maximum TSS were observed at the end of the experiment i.e. 7.9 in case of transparent and colored bottles and minimum were at the 0 day of storage i.e. 7.3 both in case of transparent and colored bottles.

The results indicated that TSS of carbonated carrot juice were increased significantly both in case of transparent and colored bottles and this increase was due to change of protopectin to water soluble pectin fraction (Bhatti, 1975). Storage temperature plays very important role in this conversion. There was no significance difference in TSS of carbonated carrot juice stored in transparent and colored bottles.

***Ascorbic acid contents of carbonated carrot juice stored in transparent and colored bottles*:** Analysis of variance regarding ascorbic acid contents of carbonated carrot juice illustrated that effect of treatment and storage and the interactive effect of treatments and storage was found to be significant both in case of storage of juice in colored and transparent bottles. Mean values of ascorbic acid contents of carbonated carrot juice are given in Table 3. The results indicated that the increase in carbonation brings a significant decrease in ascorbic acid contents of carrot juice

**Table 1: Effect of carbonation on the pH of carrot juice stored in transparent and colored bottles**

| Days | Carbonated carrot juice in transparent bottles | | | | | | Carbonated carrot juice in colored bottles | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Treatments | | | | | Mean | Treatments | | | | | Mean |
| | $T_0$ | $T_1$ | $T_2$ | $T_3$ | $T_4$ | | $T_0$ | $T_1$ | $T_2$ | $T_3$ | $T_4$ | |
| 0 | 4.02 | 3.92 | 3.91 | 3.86 | 3.81 | 3.90 | 4.01 | 3.90 | 3.93 | 3.86 | 3.80 | 3.90 |
| 15 | 3.99 | 3.80 | 3.84 | 3.78 | 3.70 | 3.82 | 3.98 | 3.81 | 3.85 | 3.77 | 3.71 | 3.82 |
| 30 | 3.91 | 3.75 | 3.64 | 3.63 | 3.55 | 3.69 | 3.91 | 3.77 | 3.65 | 3.60 | 3.53 | 3.69 |
| 45 | 3.88 | 3.63 | 3.50 | 3.51 | 3.42 | 3.58 | 3.85 | 3.67 | 3.55 | 3.53 | 3.41 | 3.60 |
| Mean | 3.95 | 3.77 | 3.72 | 3.69 | 3.62 | | 3.93 | 3.78 | 3.74 | 3.69 | 3.61 | |

$T_0$= Without Carbonation, $T_1$ = 1 % Carbonation, $T_2$ =1.5 % Carbonation, $T_3$ = 2 %Carbonation, $T_4$ = 2.5 % Carbonation

**Table 2: Effect of carbonation on the TSS of carrot juice stored in transparent and colored bottles**

| Days | Carbonated carrot juice in transparent bottles | | | | | | Carbonated carrot juice in colored bottles | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Treatments | | | | | Mean | Treatments | | | | | Mean |
| | $T_0$ | $T_1$ | $T_2$ | $T_3$ | $T_4$ | | $T_0$ | $T_1$ | $T_2$ | $T_3$ | $T_4$ | |
| 0 | 7.5 | 7 | 8 | 7 | 7 | 7.3 | 9 | 8 | 9.3 | 8.5 | 7 | 7.3 |
| 15 | 6 | 7.2 | 7.2 | 8 | 6 | 6.8 | 9.1 | 8.2 | 9.1 | 9 | 7.5 | 6.8 |
| 30 | 7 | 7.5 | 7 | 8.3 | 7 | 7.3 | 9.3 | 8 | 9.1 | 9 | 7.8 | 7.3 |
| 45 | 7.4 | 8 | 7.9 | 8.6 | 8 | 7.9 | 9.1 | 9 | 9 | 8.7 | 8 | 7.9 |
| Mean | 6.9 | 7.4 | 7.5 | 7.9 | 7 | | 9.1 | 8.3 | 9.1 | 8.8 | 7.5 | |

$T_0$= Without Carbonation, $T_1$ = 1 % Carbonation, $T_2$ =1.5 % Carbonation, $T_3$ = 2 %Carbonation, $T_4$ = 2.5 % Carbonation

**Table 3: Effect of carbonation on the ascorbic acid contents (mg/100ml) of carrot juice stored in transparent and colored bottles**

| Days | Carbonated carrot juice in transparent bottles | | | | | | Carbonated carrot juice in colored bottles | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Treatments | | | | | Mean | Treatments | | | | | Mean |
| | $T_0$ | $T_1$ | $T_2$ | $T_3$ | $T_4$ | | $T_0$ | $T_1$ | $T_2$ | $T_3$ | $T_4$ | |
| 0 | 4.9 | 5.0 | 5.0 | 5.2 | 5.2 | 5.06 | 5.0 | 5.0 | 4.9 | 5.2 | 4.9 | 5.00 |
| 15 | 4.5 | 4.5 | 4.2 | 4.36 | 4.5 | 4.41 | 4.36 | 4.5 | 4.5 | 4.38 | 4.30 | 4.40 |
| 30 | 3.81 | 4.36 | 3.81 | 4.1 | 4.1 | 4.03 | 3.81 | 4.2 | 3.81 | 3.63 | 3.63 | 3.81 |
| 45 | 3.63 | 3.45 | 2.90 | 3.63 | 3.09 | 3.34 | 4.2 | 3.81 | 3.27 | 3.27 | 2.90 | 3.49 |
| Mean | 4.21 | 4.32 | 3.97 | 4.32 | 4.22 | | 4.34 | 4.37 | 4.12 | 4.12 | 3.93 | |

$T_0$= Without Carbonation, $T_1$ = 1 % Carbonation, $T_2$ =1.5 % Carbonation, $T_3$ = 2 %Carbonation, $T_4$ = 2.5 % Carbonation

stored in colored and transparent bottles. This decrease in ascorbic acid contents was due to conversion of L- ascorbic acid to dehydrolysed ascorbic acid by temperature. Light also affects the loss in ascorbic acid contents. Maximum ascorbic acid was recorded at the start of experiment i.e. 5.00 in case of colored bottles and 5.09 in case of transparent bottles, while minimum ascorbic acid contents were observed at the 45$^{th}$ day of storage i.e. 3.34 in case of transparent bottles and 3.49 in case of colored bottles.

***Mineral contents of carbonated carrot juice stored in transparent and colored bottles*:** In this research the effect of carbonation on mineral contents i.e. calcium (Ca), magnesium (Mg), phosphorus (P) and iron (Fe) of the carrot juice was studied. The analysis of variance regarding Ca, Mg and P contents of carrot juice indicated that the effect of storage and treatment was significant both in transparent and colored bottles while it was non- significant in case of Fe contents of both colored and transparent bottles.

The results showed that with the increase in carbonation the Ca, Mg and P contents of carrot juice increased significantly both in colored and transparent bottles. However the Fe contents were not increased significantly with the increase in carbonation. Storage of carbonated carrot juice resulted in decrease in mineral contents (Ca, Mg, P and Fe) both in transparent and colored bottles given in Table 4. Overall the carbonation had very good effect on stability of Ca, Mg, P and Fe contents of carrot juice stored in colored and transparent bottles.

***Reducing sugar contents of carbonated carrot juice stored in transparent and colored bottles*:** Analysis of variance showed that effect of treatment was significant while the storage and interactive effect of storage and treatment was non-significant in case of transparent bottles. In case of colored bottles the effect of treatment and storage was significant and the interactive effect was non- significant. Mean value for reducing sugar contents of carbonated carrot juice are given in Table 4. The results illustrated that the reducing sugar contents of carbonated carrot juice was increased during storage both in case of colored and transparent bottles. This increase was due to hydrolytic changes and conversion of non-reducing sugars to reducing sugars (Zaheer, 1986). Time of storage and storage temperature affects the reducing sugar contents while the storage material not.

***Beta carotene contents of carbonated carrot juice stored in transparent and colored bottles*:** The analysis of variance indicated that effect of treatment and storage was significant while the interactive effect was non-significant both in case of colored and transparent bottles. The results showed that carbonation has very good effect on the stability of β-carotene contents of carbonated carrot juice, stored in

**Table 4: Effect of carbonation on the Ca, Mg, P and Fe contents (mg/100ml) of carrot juice stored in transparent and colored bottles**

| Minerals | Days | Carbonated carrot juice in transparent bottles | | | | | | Carbonated carrot juice in colored bottles | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Treatments | | | | | Mean | Treatments | | | | | Mean |
| | | $T_0$ | $T_1$ | $T_2$ | $T_3$ | $T_4$ | | $T_0$ | $T_1$ | $T_2$ | $T_3$ | $T_4$ | |
| Ca | 0 | 21 | 23 | 20 | 20 | 22 | 21.2 | 21 | 20 | 21 | 22 | 23 | 21.4 |
| | 15 | 21 | 21 | 20 | 19 | 21 | 20.4 | 20 | 20 | 20 | 22 | 23 | 21 |
| | 30 | 20 | 21 | 19 | 19 | 21 | 20 | 20 | 19 | 20 | 21 | 21 | 20.2 |
| | 45 | 19 | 20 | 19 | 18 | 20 | 19.2 | 19 | 19 | 20 | 19 | 21 | 19.6 |
| | Mean | 20.25 | 21.25 | 19.50 | 19 | 21 | | 20 | 19.5 | 20.25 | 21 | 22 | |
| Mg | 0 | 11 | 13 | 12 | 13 | 12 | 12.2 | 12 | 11 | 12 | 11 | 10 | 11.2 |
| | 15 | 11 | 11 | 10 | 12 | 12 | 11.2 | 12 | 10 | 12 | 11 | 10 | 11 |
| | 30 | 11 | 11 | 10 | 12 | 12 | 11.2 | 11 | 10 | 12 | 10 | 09 | 10.4 |
| | 45 | 11 | 11 | 10 | 11 | 10 | 10.6 | 11 | 10 | 10 | 10 | 09 | 10 |
| | Mean | 11 | 11.5 | 10.5 | 12 | 11.5 | | 11.5 | 10.5 | 11.5 | 10.5 | 9.5 | |
| P | 0 | 26 | 25 | 24 | 24 | 24 | 24.6 | 24 | 24 | 24 | 22 | 23 | 23.4 |
| | 15 | 26 | 24 | 24 | 24 | 22 | 24 | 24 | 23 | 24 | 22 | 23 | 23.2 |
| | 30 | 25 | 24 | 23 | 24 | 22 | 23.6 | 21 | 22 | 24 | 22 | 23 | 22.4 |
| | 45 | 25 | 24 | 21 | 23 | 22 | 23 | 21 | 22 | 23 | 21 | 21 | 21.6 |
| | Mean | 25.5 | 24.25 | 23 | 23.75 | 22.5 | | 22.5 | 22.75 | 23.75 | 21.75 | 22.5 | |
| Fe | 0 | 0.51 | 0.52 | 0.51 | 0.50 | 0.51 | 0.51 | 0.52 | 0.53 | 0.51 | 0.52 | 0.52 | 0.52 |
| | 15 | 0.51 | 0.52 | 0.51 | 0.50 | 0.50 | 0.50 | 0.52 | 0.51 | 0.51 | 0.51 | 0.52 | 0.51 |
| | 30 | 0.50 | 0.52 | 0.51 | 0.50 | 0.50 | 0.50 | 0.50 | 0.51 | 0.51 | 0.51 | 0.51 | 0.50 |
| | 45 | 0.50 | 0.52 | 0.51 | 0.48 | 0.49 | 0.50 | 0.50 | 0.51 | 0.50 | 0.50 | 0.50 | 0.50 |
| | Mean | 0.50 | 0.52 | 0.51 | 0.49 | 0.50 | | 0.51 | 0.51 | 0.50 | 0.51 | 0.51 | |

**$T_0$**= Without Carbonation, **$T_1$** = 1 % Carbonation**,** **$T_2$** =1.5 % Carbonation**,** **$T_3$** = 2 %Carbonation, **$T_4$** = 2.5 % Carbonation

**Table 5: Effect of carbonation on the reducing sugar contents (g/100ml) of carrot juice stored in transparent and colored bottles**

| Days | Carbonated carrot juice in transparent bottles | | | | | | Carbonated carrot juice in colored bottles | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Treatments | | | | | Mean | Treatments | | | | | Mean |
| | $T_0$ | $T_1$ | $T_2$ | $T_3$ | $T_4$ | | $T_0$ | $T_1$ | $T_2$ | $T_3$ | $T_4$ | |
| 0 | 5.1 | 5.4 | 5.6 | 5.6 | 5.3 | 5.18 | 5.6 | 5.6 | 5.4 | 5.5 | 5.6 | 5.5 |
| 15 | 5.3 | 5.6 | 5.6 | 5.5 | 5.4 | 5.6 | 5.6 | 5.5 | 5.5 | 5.6 | 5.5 | 5.5 |
| 30 | 5.5 | 5.1 | 5.5 | 5.1 | 5.5 | 5.34 | 5.5 | 5.6 | 5.6 | 5.5 | 5.4 | 5.4 |
| 45 | 5.8 | 5.4 | 5.3 | 5.0 | 5.5 | 5.52 | 5.1 | 5.3 | 5.4 | 5.5 | 5.3 | 5.6 |
| Mean | 5.52 | 5.3 | 5.5 | 5.3 | 5.42 | | 5.4 | 5.5 | 5.4 | 5.5 | 5.4 | |

**$T_0$**= Without Carbonation, **$T_1$** = 1 % Carbonation**,** **$T_2$** =1.5 % Carbonation**,** **$T_3$** = 2 %Carbonation, **$T_4$** = 2.5 % Carbonation

**Table 6: Effect of carbonation on the β-carotene contents (mg/100ml) of carrot juice stored in transparent and colored bottles**

| Day | Carbonated carrot juice in transparent bottles | | | | | | Carbonated carrot juice in colored bottles | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Treatments | | | | | Mean | Treatments | | | | | Mean |
| | $T_0$ | $T_1$ | $T_2$ | $T_3$ | $T_4$ | | $T_0$ | $T_1$ | $T_2$ | $T_3$ | $T_4$ | |
| 0 | 0.0730 | 0.0754 | 0.0746 | 0.0738 | 0.0762 | 0.0746 | 0.0754 | 0.0760 | 0.0758 | 0.0756 | 0.0762 | 0.0757 |
| 15 | 0.0718 | 0.0742 | 0.0734 | 0.0726 | 0.0750 | 0.0734 | 0.0750 | 0.0757 | 0.0753 | 0.0753 | 0.0758 | 0.0754 |
| 30 | 0.0710 | 0.0743 | 0.0726 | 0.0718 | 0.0742 | 0.0726 | 0.0746 | 0.0751 | 0.0749 | 0.0747 | 0.0754 | 0.0749 |
| 45 | 0.0703 | 0.0727 | 0.0719 | 0.0711 | 0.0735 | 0.0719 | 0.0743 | 0.0750 | 0.0748 | 0.0747 | 0.0751 | 0.0747 |
| Mean | 0.0715 | 0.0739 | 0.0731 | 0.0723 | 0.0747 | | 0.0748 | 0.0754 | 0.0752 | 0.0750 | 0.0756 | |

**$T_0$**= Without Carbonation, **$T_1$** = 1 % Carbonation**,** **$T_2$** =1.5 % Carbonation**,** **$T_3$** = 2 %Carbonation, **$T_4$** = 2.5 % Carbonation

transparent and colored bottles. Storage of carbonated carrot juice resulted in decrease in β-carotene contents. The stability of β-carotene contents was better in colored bottles than in transparent bottles during storage.

***Organoleptic evaluation*****:** Organoleptic evaluation was performed by hedonic scale at the intervals of 0, 15, 30 and 45 days. Color of carrot juice having 1% carbonation got highest marks while the lowest marks were obtained by the treatment having 1.5% carbonation. The score went on decreasing in all treatments during storage. However all the treatments remained acceptable organoleptically during storage except the treatment containing 2% carbonation. Same was the case with flavor, taste and overall acceptability.

## CONCLUSION

The research showed that the carbonation of carrot juice brings decrease in pH and ascorbic acid contents and increase in TSS and reducing sugars. Moreover carbonation had also a very good effect on the mineral contents of the carrot juice. In case of organoleptic evaluation all the treatments remained acceptable for color, flavor, taste and overall acceptability.

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